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Technology Support for Performance Assessment of Road Haulage

Abstract: *Recent developments in wireless technology and telecommunication have made possible new types of information systems supporting fundamental activities in transport organisations. By including previously inaccessible distributed and mobile actors and equipment, this technology is a key enabler for realising the vision of integrated enterprise systems in this context. In this thesis, I focus on a particular type of transport organisation, that of road haulage firms. The term transport information systems (TIS) is used to discuss a specific type of enterprise technology, incorporating mobile aspects as well as the relevant functionalities of present enterprise systems. To capture the typical characteristics of Swedish road haulage firms and their general understanding of TIS, a qualitative interview study including 18 road haulage firms was performed. Building on the results of the study is a number of design challenges for successful adoption of such systems in this particular type of transport organisation. A subset of these design challenges is further examined through developing a prototype integrating vehicle performance data and assignment transaction information.*

Keywords: Enterprise Systems, Road Haulage, Transport Information Systems, Telematics

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1. Introduction

Rapid developments in wireless technology and telecommunication have made possible new types of information systems supporting fundamental activities in transport organisations. While this is a novel development, organisations facing intense competition have historically viewed information technology as a means to improve internal performance. For decades, information systems have been developed to increase productivity in a wide variety of business functions. Typically, continual IT-driven improvements have resulted in a plethora of in-house developed systems, dealing with specific subsets of the entirety of an organisation's business activities. While such systems may alleviate the problems that they were designed to address, a consequence is the fragmentation of the information system support when applying a strategic view of the entire organisation (Markus and Tanis, 2000; McKenney and McFarlan, 1982). This state of affairs created a market opportunity for a new type of enterprise systems that has become known as enterprise resource planning (ERP) systems. The main purpose of these systems is to remedy the information fragmentation of the function oriented legacy systems (Davenport, 1998). This is typically achieved by incorporating functionality, similar to that of previous legacy systems, as modules in an enterprise wide system intended to support all business activities in one bold leap.

Whether or not ERP systems deliver as promised is still a subject of intense debate (Pozzebon, 2001). Stories of success compete with reports on unsuccessful attempts to integrate the previously isolated flows of information in companies (see e.g. Parr and Shanks, 2000; Larsen and Myers, 1999). Indeed, it remains to be seen if the specific monolithic ERP architecture or a system consisting of loosely coupled subsystems is the way forward. Beyond doubt, however, ERP and enterprise wide systems in general have become a topic of interest in IS research.

Here the attention is directed to a particular type of transport organisation, that of road haulage firms. The typical road haulage firm coordinates a geographically distributed workforce constantly moving with the trucks, providing timely pickup and delivery of goods. Recent advances in mobile and wireless communication technologies have enabled the development of a wide

range of applications supporting these daily activities. Tactical IT tools include the positioning of trucks and their cargo, the recording of performance parameters from the vehicle, and the wireless communication of data from some or all of these tools. The positions of individual trucks can be presented on maps, offering the dispatcher a quick overview of the geographic distribution of the resources. Route calculation done by the driver in the field or by the dispatcher is intended to minimise the cost of an assignment in terms of time and fuel expenditure. Road haulage firms are starting to implement these support tools, indicating that these organisations have needs in excess of those addressed by conventional enterprise systems. The vision of an integrated enterprise system, as embodied in ERP, is a metaphor of great importance in this thesis. Here, the term transport information systems (TIS) is used to discuss a specific type of enterprise technology, incorporating the above mentioned mobile aspects as well as the relevant functionalities of present enterprise systems.

To understand the requirements of enterprise wide systems for road haulage firms, it is necessary to explore their needs and experiences of technology. IS researchers have suggested several different theoretical frameworks for studying IT adoption in organisations. In this research, Orlikowski and Gash's (1994) technological frames approach serves as inspiration in the quest to explore assumptions, knowledge, and expectations of the role of TIS in the context of road haulage firms. Building on results from a qualitative interview study specifically designed to capture typical characteristics of Swedish road haulage firms and their general understanding of TIS, the contribution of this thesis is a number of design challenges for successful adoption of such systems in this particular type of transport organisation. A subset of these challenges is then used to inform the design of a prototype developed to further illuminate these specific issues.

This thesis proceeds as follows. First, a description of the technological frames framework is provided, including an explanation of the specific application of the technological frames approach. This is followed by a presentation of the research context and the method applied. Then findings from the empirical study are presented. In the discussion of the research results, I elaborate on a number of design challenges important for successful TIS adoption in road

haulage firms. Some of the findings are then taken one step further, forming the basis of a prototype.

2. Theoretical background

Much research has focused on how individuals make sense of and assign meaning to their environment, organisation, and task. Most researchers suggest individuals to have mental models that they use to interpret and understand their surroundings. These models are also recognised to form the basis for producing action (Weick, 1979; Kiesler and Sproull, 1982; Porac et al., 1989). While stressing that mental models or interpretive schemes constitute an important foundation for humans' individual interpretations and actions, many researchers argue that members of a particular community have a set of core beliefs in common (see e.g. Porac et al., 1989). Being shared by different individuals, these commonly held frames of reference could be seen as results of socialisation processes (Berger and Luckman, 1967).

Gioia (1986:50) defines frames of reference as "definitions of the organisational reality that facilitate perception, understanding and action". Individuals' frames of reference include assumptions, knowledge, and expectations, communicated symbolically through language, visual images, metaphors, and stories. Typically operating in the background, frames of reference have both facilitating and constraining effects. Whereas frames of reference can be described as helpful in that they, for example, structure organisational experience, allow interpretations of ambiguous situations, and provide a basis for action, frames can also inhibit creative problem solving and reinforce unreflective reliance on existing assumptions and knowledge (Gioia, 1986).

According to Orlikowski and Gash (1994), a subpart of people's frames of reference is about technology. Coining the notion of technological frames, Orlikowski and Gash theorise how users apply assumptions, expectations, and knowledge to understand and make sense of technology in organisations. Examining taken-for-granted conceptions of technology in organisations, they assert, can provide an understanding of the role and consequences of technology in a specific situation, place, time or project. In other words, such an understanding includes both the technology as such and its role but also specific

states of affairs that consequences of technology have in a particular context. Orlikowski and Gash argue that social groups in organisations will develop or carry different technological frames because of their roles and relations with technology. For example, managers tend to have a strategic understanding of technology, expecting it to support new ways of doing business and hence generate profit. On their part, users typically focus on how technology can be deployed to facilitate everyday tasks. An assessment of the technological frames of particular actor groups can thus facilitate the prediction of potential difficulties and conflicts associated with a specific introduction of an information system in an organisational context. By illuminating the views held by a group of actors it also helps understand their specific requirements of technology.

In view of the ambition to understand needs and experiences of TIS as perceived by road haulage firms, the technological frames approach is an appealing option. However, rather than cross-examining statements within a set of different typical actors this study targets knowledgeable individuals in several road haulage firms. The rationale behind this approach is the aim to explore assumptions, knowledge, and expectations of TIS in the Swedish road haulage business sector through the lens of influential individuals likely to have a decisive impact on the implementation and use of IT in their organisations. The aim is to capture is these individuals' general notion of the role of TIS in the everyday practice of road haulage firms.

3. Research context and method

3. 1 The anatomy of Swedish road haulage firms

Road haulage firms typically transport some kind of goods from one place to another using a truck. At first glance, these organisations appear to be similar, dealing with the same slice of reality often in similar ways. The most obvious example suggesting such similarity would be that trucks, drivers, and transport activities constitute the core of the organisation. However, the road haulage business sector is far from homogeneous in that core business activities, organisational structures, and size vary. Road haulage can be characterised as a diversified line of business, covering both local distribution of goods requiring

loading and unloading several times each day, and long distance transports where it can take days between loading and unloading. Accordingly, the structure of the work differs, ranging from rather static work where transport activities can be planned ahead to dynamic situations in which assignments have to be communicated to the driver during the day.

Regardless of the actual set up in different organisations, there are a number of roles typically found in a road haulage firm. These roles are dispatcher, driver, management, and vehicle maintenance personnel. A dispatcher handles the incoming assignments and organises drivers and trucks, being the resources involved in transporting goods. This work involves many tasks, ranging from contact with clients and drivers to resource control and coordination. A driver transport goods, performing tasks such as loading, unloading, and the actual driving as well as contact with clients and the planning of routes. Managers are responsible for long term economic planning and follow-up. Finally, there are personnel involved in activities such as vehicle maintenance, supervising of fleet status, service time scheduling, and the changing of tires. Some road haulage firms run a repair shop themselves, others outsource most of the maintenance function. The borders of all of the above task related roles are fluent. Depending on business size, the same person can have more than one role, or several persons can have a similar role. The larger the organisation, the more specialised personnel you are likely to find.

The Swedish Road Haulage Association states that in the late 1990´s, almost 90% of their members operated approximately five vehicles, indicating that most Swedish road haulers are small firms. In the current situation, the Swedish transport industry undergoes changes occasioned by European Union's "open market". For example, foreign transport firms have increased their share of transportations considerably, which is a direct result of the fact that the cost level is lower in nearby countries (15-20% lower in countries such as Denmark, Germany, and the Netherlands, and 30-40% lower in countries such as Poland). This cost disadvantage has resulted in minimal profitability margins for small and independent road haulage firms. In this context, contractors of haulers like Danzas and Schenker have strengthened their market positions. To improve their competitiveness, road haulage firms are starting to implement different types of IT support. Analogous to IT investments in other types of organisations,

the size of road haulage firms is an important factor in that it determines the available amount of resources for procuring and administrating IT support. As a practical implication, most Swedish road haulage firms rarely afford to develop a custom-built system, forcing them to consider the various "off-the-shelf solutions" available. In many situations, the wide variety of business activities in road haulage firms makes this choice complicated and sometimes even impossible, though. However, it seems that road haulers try their best to overcome such struggles associated with implementing advanced technology, indicating a desire to explore the potential benefits that adequate IT support could bring.

3.2 Researching Transport Information Systems

This study is part of an action research project named "Value-Creating IT for Road Haulage Firms". Intended to generate general guidelines for how TIS should be developed and implemented based on the needs of road haulers, the project is conducted as a collaborative effort where researchers, systems vendors, and truck manufacturers develop, implement, and evaluate TIS together with road haulage firms. Project members include the Viktoria Institute (IT-research institute), road haulage industry representatives (The Swedish Road Haulage Association, The Road Haulage Association in the West of Sweden, and a number of road haulage firms), systems vendors (Hogia, NL Partner, Transics, and Vehco), and truck companies (Scania and Volvo Trucks).

The ideal or 'canon' action research cycle according to Susman and Evered (1978) consists of five stages. These are diagnosing, action planning, action taking, evaluating and specify learning. The diagnostic phase is where the identification of the main problems and the associated need for change. Maintaining a holistic perspective is essential and problems should not be reduced to minute detail levels at this early stage. The result should be a broad working hypothesis of the organisation and the problem domain. In the subsequent action planning phase actions designed to alleviate previously diagnosed problems are described. The knowledge gained from the previous phase is used to illuminate a desirable future state how to obtain it. The planned action is then put into practice in the organisation. This work is conducted as a collaborative effort between researchers and practicians. The execution of the

prescribed action is then followed by a joint evaluation of the effects of that action. The end phase activity is to ascertain whether the actions taken have alleviated the previous problems but also to determine whether this was due to the taken action specifically, or to other factors. If problems are found to remain, another iteration takes place. Learning is continuous throughout the action research cycles. For the organisation studied, this can entail new insights pertaining to the organisation itself. For researchers, the acquired knowledge of theories in practice serves as valuable input in further research endeavours. The different phases are distinct and structured. However, throughout the process they influence each other iteratively. Further, it is important that the process dictate the method. (Susman and Evered 1978).

However, of the different stages included in the action research cycle as defined by Susman and Evered (1978), it is important to note that the study presented here is part of the early diagnosing and action planning phases. While the overall research project is directed towards IT support for road haulage firms, this study is the first activity in which the concept of TIS as seen through the eyes of the users in this particular line of transport business is investigated. The results from this initial work are to serve as first input into future research activities where the findings form the basis for further studies in situated organisational contexts within which specific actions will be planned and executed. While these future activities are beyond the scope of this study, this is the research context in which this thesis resides.

The main empirical data was collected in a series of 18 interviews with key personnel in various road haulage firms in the autumn of 2002. The Swedish Road Haulage Association, representing approximately 11000 contractors with some 30000 vehicles and machines, recommended a number of potentially interesting member road haulage firms. The choice was based on their level of experience acquired through advanced usage of specialised IT-support in day-to-day practice. These organisations were diverse in terms of core business, structure, and size. This diversity was beneficial in view of the attempt to understand the situation experienced by road haulage firms in general. Examining potential similarities and differences between organisations, a choice was made to interview influential individuals in leading managerial positions. This was mainly due to the fact that most road haulage firms are small, well

within the size of what is known as small and medium sized enterprises (SME's). Due to the limited size and complexity of small and medium sized firms, managers are usually involved in every organisational process and tend to have a comprehensive perspective of all organisational issues (Calderia and Ward, 2002). Besides the managerial perspective of the interviewees, most of these individuals also have previous personal experience of the truck driver or the dispatcher roles, thus providing an interesting source of information on these roles as well.

Intricate organisational interdependencies with substantial situational variations can be hard to identify using formal methods for collecting data (Walsham, 1995). Exploring the assumptions, knowledge, and expectations of individuals in a given context, it is necessary to "mine" rather than "survey" the terrain (McCracken, 1988). It is impossible to fully comprehend the questions that generate the desired understanding in advance. Therefore a qualitative approach was chosen. Consequently, in order to acquire a rich picture of the actions and processes in the organisations, the primary method for the data collection was semi-structured interviews, lasting between one and two hours. This technique has the potential to illuminate potential particularities of the individual organisational settings in question, by allowing forming and reforming of alternative questions as well as detailed explanations and interesting detours whenever necessary (Walsham, 1995). However, some structure is retained so that there is satisfactory correlation between the different interviews. The data was then approached in an open-minded manner, meaning that the data itself suggested concepts and categories. The concepts and categories were revised and refined until they sufficiently explained all data. The empirical findings can thus be said to have emerged from an iterative and interpretive analysis of the collected data (Walsham, 1995). The categories emerging were used as input in an intermediate literature study, aimed at further illuminating a subset of them.

This revised set of empirical data coupled with information gained from the literature study served as input in a prototype development project. The original plan was to utilise the information processing capabilities of two kinds of systems; a vehicle management system and a cargo/fleet management system. Vehco, the firm behind CoDriver, a brand independent vehicle management

system, would provide the vehicle performance data necessary. However, only the vehicle management system was available at the time of the development phase. Although this meant that a cargo management module had to be developed as part of the prototyping venture, the decision was made to go ahead. After a prolonged development phase, the completed prototype was then evaluated by a focus group, consisting of key personnel from a large road haulage firm. It was also discussed with the cooperating software firm. The results from the evaluation were compared to the assumptions made prior to the prototype development. Finally, a complementary literature review was performed to help interpret the evaluation.

The work process

4. Transport Information Systems in road haulage firms

On the basis of the qualitative interview study covering influential individuals assumed to have a decisive impact on the implementation and use of IT in their organisations, this section presents assumptions, knowledge, and expectations of TIS in the context of road haulage firms. Structured around roles normally found in a road haulage firm, the assumptions, knowledge, and expectations presented are suggested to capture typical aspects of the role of TIS in this particular type of transport organisation. Although these aspects can be seen as illustrative dimensions of the general nature of technology use in road haulage firms, they are not claimed to be exhaustive. Additional empirical investigations of road haulage firms and their general understanding of TIS are likely to add or modify the aspects captured.

4.1 Traffic controller

One fundamental aspect of traffic controllers' everyday work is communication. Interacting with both customers and drivers, traffic controllers are dependent on fast, reliable, and efficient communication channels. In most road haulage firms, this interaction is mainly handled by phone. However, several of the

respondents argued that such heavy telephone usage is both stressful and time consuming. Describing the current situation in his firm, one interviewee said:

"As it turns out there are many incoming calls to the office, which is problematic. Not only do the drivers call, but also customers and contractors of haulers and what have you. It can be quite overheated there. So the idea is, although it sounds strange, that we try to talk to the drivers as little as possible, just so that the situation becomes both effective and manageable."

An opinion shared among many road haulage firms was that technology support for communication between traffic controllers and drivers is an important issue, in that it can reduce the firm's internal phone use. According to the respondents, sending formalised transport order data to the truck instead of using phone is beneficial for traffic controllers in several ways. One problem associated with telephone-based communication was the time spent failing to reach the driver, already talking to someone else, or working outside the truck. By sending textual messages, traffic controllers do not have to rely on synchronous communication. Also, written data is assumed to be more exact than spoken messages, thus reducing misunderstandings. As illustrated by one of the interviewees, facilitating the communication between traffic controllers and drivers is a main concern for most road haulage firms today:

"[It is important] to get the orders out and communicate with the drivers in an easier, smoother way so that the communication part of planning transports becomes easier. They [the traffic controllers] are spending two hours a day talking to the drivers using mobile phones - get rid of that. Traffic controllers are really stressed these days and we need to reduce their workload. That is what it is about; to send the orders easily and smoothly to the drivers."

Another aspect of traffic controllers' work is to monitor resources. Awareness of the status and location of drivers and vehicles at any given time is vital for assigning incoming orders during the day. Recurring topics in the interviews

were the proximity to pick-up site, drive time left, and cargo space available. One respondent shared his vision of a positioning system that would facilitate traffic controllers' work:

"A dream would be to have a complete map over the whole district. Then you could see the vehicles, how they move, and how much cargo they carry. That would have been perfect; it would make their job so much easier. Although you can never replace humans, a lot can be done to assist a person in taking decisions and making choices."

Resource management also includes awareness of the equipment of each vehicle and the competence of each driver. Certain assignments require a specific type of truck, which in turn demands specific competences and certificates on behalf of the driver. Also, personal relations can be of importance and customers sometimes insist on a specific driver. This mapping of customers and drivers is an additional responsibility of the traffic controller. Throughout the interviews, it was evident that the traffic controllers were a crucial asset to the road haulage firms. The interviewees frequently mentioned the capabilities of their traffic controllers and the importance of their role, acting as a hub in the information flow of the whole organisation. Most road haulage firms included in the study considered sophisticated system support for the traffic controller function to be of strategic importance.

4.2 Driver

As distributed workers, drivers frequently rely on remote communication to perform their work. They receive transport orders from the office and contact traffic controllers, updating their work status, or in case of problems. In the participating road haulage firms, mobile phones were the drivers' primary tool for information exchange. The respondents recognised that sending order data between the office and the truck brings significant benefits to drivers, similar to those of traffic planners. Although a system for data transfer between the truck and the office reduces the phone communication between driver and traffic planners, it does not make the mobile phone redundant. According to some of

the interviewees, drivers often need to talk to the client at the delivery site. In spite of the advantages of a system for mobile data communication, he assumed that the drivers will always need mobile phones for some types of communication:

"The clients demand that he [the driver] can call when under way. I would say that they call three or four clients out of ten. Regardless of what kind of mobile communication system we get, they can never manage without the mobile phone."

In addition to contacting traffic controllers and customers, drivers occasionally need to coordinate with each other. Besides the need for work related communication, some of the interviewees implied that the solitary nature of drivers' work situation makes the possibility to communicate essential from a social perspective. While the costs of calls made outside strictly work related situations were seen as a problem, many argued that it was necessary in order to maintain a positive attitude towards work among drivers. The balance between mobile phone communication and formal textual messaging was considered to be a crucial issue.

In certain situations, finding the optimal way to a pick up- or delivery site can be problematic for drivers. The interviewees recognised the role technology can play in supporting this activity through the combination of different sources of information. These sources include static information, for example about passages or bridges were heavy traffic is not allowed, and information about dynamic events such as traffic congestions and road constructions. One of the interviewees shared his expectations and assumptions about this type of technology:

"I have been thinking about some kind of route planning system. We could make money by shortening the driving distance. We should have a system keeping you from driving under a bridge that is too low, or ending up on a

road where you are not allowed to drive because the truck is too heavy. And maybe the system could take into account the traffic situation as well. I think they can do that nowadays."

Drivers need to keep track of their driving hours and breaks in order to drive safely and legally. An assumption shared by the road haulers in the study is that real time information about driving hours and breaks can facilitate the drivers work situation and planning. Furthermore, they often manually record certain data, for example working hours and fuel receipts, in written reports. One interviewee expressed his notion of the advantages that automatic collection of this data would bring to the drivers:

"This only makes it easier for them [the drivers]. They do not need to worry about anything else than pushing these buttons. Then they get a list that they check before the salary is paid. If there is a discrepancy, they can point that out."

An important aspect of the drivers work is of course the actual driving of the truck. Considering the ever-increasing fuel prices, many of the interviewees pointed out the benefits of using technology support for minimizing fuel consumption. Today, there are several system vendors that offer applications intended to provide the driver with instant feedback on driving performance. In addition, some of the respondents highlighted the importance of educating the drivers accordingly. Courses on how to drive trucks economically and ecologically, so called heavy echo driving, are available. However, there were difficulties in maintaining the benefits from such education. In particular, two challenges were mentioned by the interviewees. First, sustaining an improved driving behaviour was viewed as difficult, and second, there was an experienced trade off between carrying out assignments as quickly as possible and driving as economically as possible.

4.3 Management

As previously stated, the drivers create reports on their working hours. These reports are then used as input to calculate salaries. Most road haulage firms included in the study used dedicated IT support for this operation. However, the information had to be fed into these systems by hand, which was perceived as an unnecessarily time consuming task. As always when manual transfer of data is involved, there is the risk of human error. There is also the element of control. A reoccurring topic among the interviewees was the difficulty to check if the reported work hours were correct. This was the area where potential problems associated with the confidentiality of the drivers seemed most important. While such aspects were acknowledged, the benefits were assumed to outweigh the potential political problems that might arise. The following account depicts one respondent's experience of such a system:

"The main reason why we invested in on-board computers was the reporting of working hours. [...] Most drivers are really good at reporting, but you know, fifteen minutes here and there. Fifteen minutes a day per employee and year amounts to quite large sums. We have had drivers reporting both seven and eight hours extra per week. [...] We can se when they have started [working] and we think that it is good because it is fair on the drivers. I think that those who have nothing to hide have nothing to fear."

One primary concern among respondents was the amount of time elapsed from completion of an assignment to invoicing. Without assistance of wireless communication, invoicing was generally not possible until the driver returned to the office with bills of laden. Depending on the character of the assignment, this could take days. Interviewees frequently mentioned the detrimental effects of delays of any kind in this process on the cash flow of the firm. The manual handling of such documents was also demanding in terms of personnel. Many road haulers had also noticed that such documents go missing at times. The task of controlling this process was a major concern in itself. In this area, the expectations of the gains of technology were high, and one respondent regarded this being the main reason to invest in IT:

"Why do we need this type of system? So that we can send the bills earlier, that is why. That is the only reason; otherwise we can use pen and paper. We want to send the bill as soon as the transport is carried out, that is were we can make money. The rest of the system is not very important just as long as it makes us able to bill five to ten days faster. If we can shorten the invoicing time five to ten days, the investment in a system would not be a great burden."

In their constant search for efficiency, managers required an extensive supply of stored information. The sources of information included numerous paper documents such as time reports, fuel receipts, and cargo receipts from the different vehicles and drivers. Technology was assumed to have great potential in facilitating easier access to a wide range of information sources, as envisioned by one of the interviewees:

"I think that when you have access to all this statistics [in a system], you could find informative ratios. You earn less on some transports, of course, but it would be interesting to see. If you get a comprehensive view of the costs, including work hours, then you can see how capable and efficient a driver really is. You need to include the cost of salaries when you calculate how profitable a transport is. Costs for service and repairs should also be included, because you need to see when the vehicle is becoming expensive, when it gets unprofitable."

As shown by this quote, some managers would also have liked to study how efficiency was distributed among the drivers. At the time of the study, any thorough analysis was considered prohibitively time consuming and, given the workload of the managers, not performed as often as most of the respondents would have preferred. Consequently, optimisation was considered complicated at best and there was a wide spread feeling that less profitable assignments went unnoticed at the expense of potential cash cows.

4.4 Vehicle maintenance

Many of the road haulage firms participating in the study assumed that technology can play an important role in improving vehicle maintenance. The road haulage firms recognised the advantage of knowing how well a particular truck is running in order to prevent massive breakdowns and subsequent disruptions in the workflow by attending to the problems early on. The following account describes experiences of the usefulness of such diagnostic features:

"Having such a system is quite interesting because you can see the condition of the trucks. Consider the Scania trucks, which have had problems with the distributors in the engines. We noticed tendencies before there was anything seriously wrong with the trucks. A closer examination showed that the distributor was faulty, so it [the system] is actually really good."

Drawing on experiences from use of technology, one respondent acknowledged the benefits of a maintenance log containing all aspects of information about individual trucks. In this case, the primary advantage was improved statistical material and simplified maintenance scheduling:

"We have a really good maintenance program now. You put in anything you want and you get service orders, when the vehicle is up for service and testing and so on. And you also get a lot of historical accounts of costs, like if some vehicle is expensive regarding tires or fuel or something. That is really good actually. The next step might be to connect it directly to the vehicle, as Volvo and Scania are doing, so that you do not have to feed all this data into it. That is excellent."

Knowledge of the possibility to automatically record and receive vehicle data raised the expectation of further improvements by reducing manual handling. However, few saw any immediate feasibility of such improvements. This was attributed to the fact that most road haulage firms had a mixed fleet of trucks.

Discouraged by incompatibility issues between different systems for different truck brands, most of the interviewees did not intend to invest in such technology.

5. Design challenges

The knowledge of the interviewees in the study ranges from a vague picture of the role of TIS, to a clear view of its potential. Expectations among the respondents on technology are high, and they assume a clear impact on business performance in several areas. Drawing on the knowledge, assumptions, and expectations from the respondents, what follows is a number of extracted challenges for the design of TIS for road haulage. These challenges concern, in order, the contextualised nature of mobile communication, mobile resource control, mobile coordination, process automation and organisational performance assessment.

New technology presented to road haulage firms makes it possible to reduce spoken communication and replace it with the transfer of formalised information via wireless data communication. As indicated by the empirical analysis, road haulers are primarily focusing on the positive impact on traffic planners work situation and the potential for improved efficiency. A reduction in the communications cost is also a motivating factor as this can facilitate return on investment calculations.

Facilitating control of resources is a vital task for enterprise wide systems (Markus and Tanis, 2000). Road haulage firms, constituted mainly of a distributed and constantly moving workforce, are aware of the benefits residing in technological support for this purpose. This area is receiving much attention from systems vendors and commercial packages are available. Supportive features include the real time positioning of vehicles, dynamic information on estimated time of arrival, and available driving time for individual drivers. Providing dispatchers with the means to make an informed decision on whom to assign urgent orders to during the day, these features eliminate the need to extract such information individually from each driver.

Technology also entails opportunities for improvement on behalf of drivers work situation. For example, by providing information in a swift and secure

way, system support for formal communication can improve traffic safety for drivers. Other features mentioned by road haulers are positioning, digital maps, route planning, and navigation support, which can increase security for the driver as well as facilitate efficient transports. These features may serve as motivating factors ultimately creating a general use incentive among drivers and encourage other use of technological artefacts with less of an obvious user benefit. Investigating how to use technology in ways that entail benefits for drivers as well as utilises the full potential of improvement on the road haulage firm, as a collective is a serious challenge.

As shown in the empirical analysis, an important reason to invest in TIS is the promise of improved efficiency by automation. Rationalizing routine tasks and processes is a classical purpose of an information system (Leavitt and Whisler, 1958). Recent technological advances have brought such promises also to mobile organisations. In the road haulage context, there are tools that greatly reduce the human effort in dispatching, invoicing, and auditing by ensuring an unbroken flow of information throughout a cross-functional geographically dispersed process. This is a situation bearing several similarities with the isolated functional systems, the islands of automation, preceding the ERP-systems boom of the nineties. Reducing the manual input in this and other processes will have direct consequences for a number of organisation members, the most obvious being potential staff reduction with maintained or increased productivity as a primary goal. In the above-mentioned case, improving cash flow is a motivator for this kind of investment.

According to the empirical analysis, the distributed mobile nature of road haulage firms makes it difficult to assess organisational performance. Utilizing vehicle data, new sources of potential knowledge have become available for road haulage firms. Formalised processing of assignments within the confines of a TIS combined with automated instant retrieval of vehicle performance data facilitated by wireless communication would ensure constantly updated sources of timely information. In filtering and combining these sources of information lies the potential of increased understanding of the organisation. So far, lack of sufficient information combined with a low degree of integration of separate function-oriented systems constitute major obstacles in these areas. However, with fully integrated TIS, the arduous task of collecting and structuring multiple

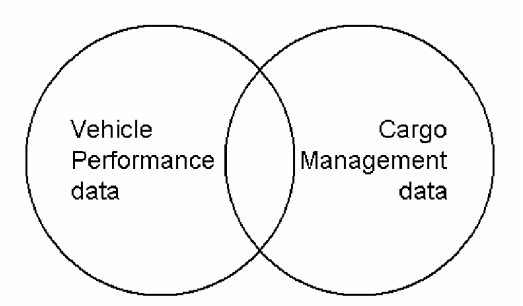
information sources of disparate format may soon become history. Granting management access to a vast source of information, Holsapple and Sena (2003) note that fully integrated enterprise systems have characteristics of strategic decision-support systems. If this applies also to TIS, remaining are the questions of what information is relevant and to what extent the instant availability of that information will change the actual decision-making process in this particular organisational context.

6.Technology Support for Performance Assessment

Of the design challenges elicited by the analysis, the areas concerning automation to some degree, and more importantly, performance assessment were chosen for prototyping. As previously mentioned, road haulage firms felt it difficult to acquire a full picture of the organisational activities for various reasons. The manual handling of documents combined with isolated islands of automation manifested by separate systems for separate functions is reminiscent of the debate leading to the ERP-strategies of the nineties. Of a far smaller scale, the prototype focuses on the relation between information generated from assignments and vehicle data and administrative information generated in the office. More specifically, the prototype is an attempt at combining information on cost and revenue to grant users a tool for quickly assessing outcomes of assignments. Information on cost includes vehicle costs, such as fuel, tires, depreciation, and salaries. Information on revenue is the actual price paid by clients for performing transport assignments. An underlying assumption is that road haulage firms would benefit from having timely access to these two types of information. Further, by permanently connecting these types of events at the very instant that they occur, the effort of collecting and combining different sources of information associated with organisational performance assessment is presumably reduced considerably.

There are numerous systems designed to facilitate the coordination of a vehicle fleet today. The basic systems consist of stationery office applications designed to aid a dispatcher in his daily tasks. More advanced systems include means to transmit assignment information between a dispatcher and a host of drivers,

thus reducing time consuming phone conversations and consequently increasing the leverage of dispatchers. Typical features are assignment scheduling, i.e. which truck gets which assignment, and tools for calculating prices on incoming assignments. Of more recent date are vehicle management systems. Here the focus is on the truck and the driver. An onboard system records vehicle performance parameters and driver related events. Tightly coupled to drive style education, so called Eco Driving, information on driving behaviour and vehicle status is displayed to the driver in the truck as well as to other personnel elsewhere in the organisation. This information is used to track down unnecessary costs and to promote optimal driver behaviour. However, these two system types are indeed islands of automation, and the purpose of the prototype is to explore potential synergies residing in their intersection, with the primary aim of aiding in assessing organisational performance. More specifically, to estimate the net profit of assignments by utilising extensively automated information retrieval.

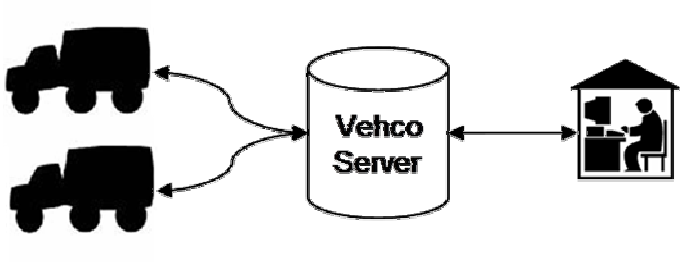


Two separate sources of information, the intersection suggesting potential synergies.

6.1 CoDriver – Vehicle Management System

The prototype is based on a commercially available vehicle management system, CoDriver, developed by Gothenburg based Vehco. CoDriver offers in-office real time access to vehicle data and a rudimentary messaging functionality. The system hardware consists of a handheld computer with a GPRS modem and connected equipment facilitating the reading of the vehicles controller area network (CAN) bus. Data from the CAN bus is continually interpreted on the handheld device. This enables continuous monitoring of several parameters such as fuel consumption and vehicle speed as well as local time and various

derivatives. The vehicle data is then immediately transmitted, using the GPRS modem, to a central server and customers use a client application to access their data presented in a number of report formats. Reports concern driving times and fuel consumption and can be utilised to monitor unnecessarily lengthy periods of idling or excessive speeds. It is also possible to view the current vehicle activities of the entire fleet.



Rough sketch of the Vehco arcitecture.

CoDriver is brand-independent, which promises equal efficiency in all the vehicles of a mixed fleet. On top of this, utilising the wireless link between the office and the trucks, CoDriver has a messaging module. This is an email style client where free text messages can be sent between dispatcher and driver. Although this could be used for coordination purposes, the lack of formalised messages and replies coupled with the need to write numerous lengthy messages on the vehicle PDA make this a poor strategy. To sum up, CoDriver has the necessary requirements to facilitate the efficient transfer of information between office and truck, with the main purpose to track dynamic cost related information. Considering the fierce competition in the road haulage business, accurate timely metrics on cost related performance is indeed viewed as beneficial by many road haulage firms. However, besides the rudimentary messaging functionality, Co Driver lacks any form of assignment functionality.

6.2 Prototyping Performance Assessment

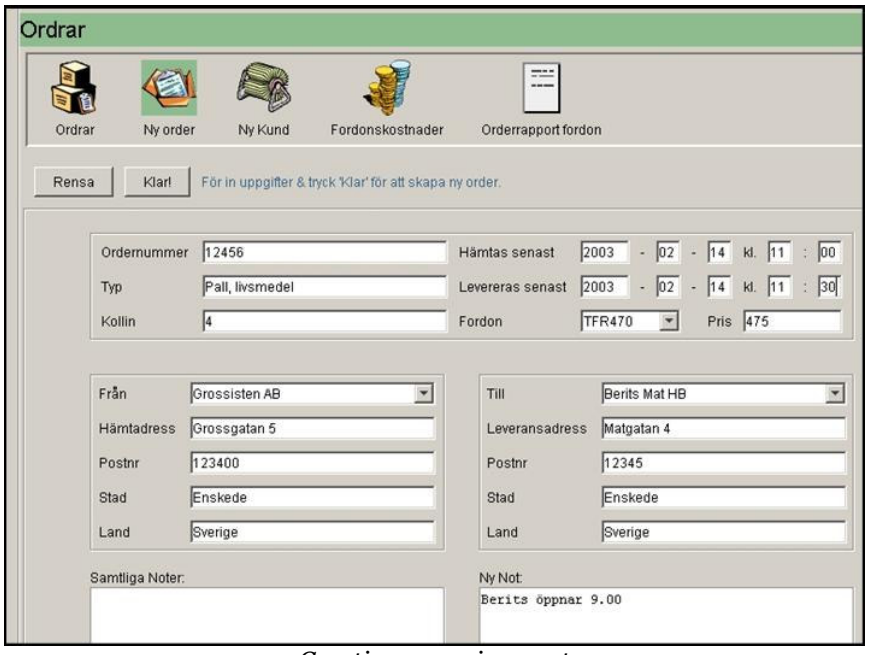
To assess the net outcomes of individual assignments carried out by the road haulage firm, cost and revenue would have to be jointly investigated. While key information on cost associated with carrying out assignments is available in the CoDriver system, it holds no information regarding the revenue of the assignment. Such information is generally available in a separate cargo

management system, although in some cases, a road haulage firm employs no system support for these activities.

There is currently no formalised information on cargo status available. To gain access to information on assignments carried out in an accessible format, thus illuminating revenue, it was therefore necessary to provide such functionality. At the time, there were plans to integrate CoDriver with a purpose built dispatch system. However, these plans failed to materialise for a number of reasons beyond the control of the author. Consequently, as a first step, the author developed a simplistic yet fully functional transport management module on top of the CoDriver platform, including an office client, an integrated server module and a vehicle client. Utilising the CoDriver platform, information on updated assignment status now arrived to the office along with the vehicle data. There are many potential advantages in integrating a fully-fledged dispatch system and due to resource limitations, mainly the temporal aspect of developing such a system single handily, some functionality could not be included in this prototype. The result is a dispatch system, capable not only of logging assignments, but also vehicle performance data connected to them. This connection is utilised in a report tool where the recorded organisational activities together form a picture of the outcome of individual assignments.

6.3 Use Case Scenario – Operational Use

To give the reader an understanding of the process of handling an assignment, what follows is a description of the prototype in use. Descriptions cover office as well as vehicle clients. First, the process of assignment execution is described, involving both office and vehicle clients and users. Second, the use of the office report tool is described. Starting with the assignment execution, the process begins with an incoming order, promptly entered into the office client GUI by the dispatcher. Type and assignment number is presently entered arbitrarily. A price also needs to be set for the assignment, as well as deadlines for pickup and delivery. A reoccurring feature is the notes area, where new notes of any shape can be added to a particular assignment. The particular truck, designated by the licence plate number, can be determined now, or at a later stage.



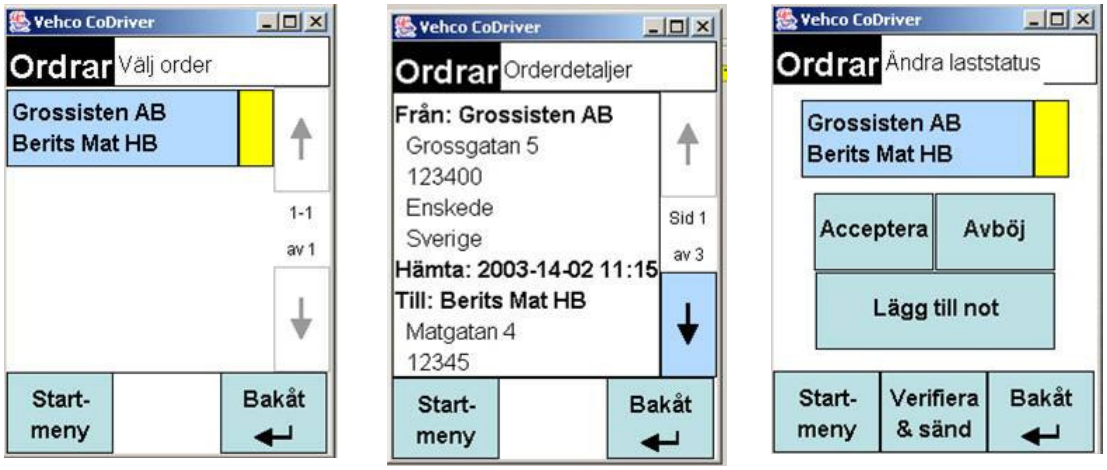
Creating an assignment

Recently created assignments immediately appear in the overview window. Here, the most important assignment attributes are shown together with the current status, one of new (white), sent (yellow), loaded (blue), delivered (green), or declined (red). Selecting a vehicle for new assignments can be accomplished by selecting one from the list embedded in the table. Double clicking brings the user to the detailed assignment view, where further changes

can be made. Rudimentary filters and sorting tools are supplied to ease the use and overview. The user can chose to send assignments to individual vehicles one by one or to all vehicles at once.

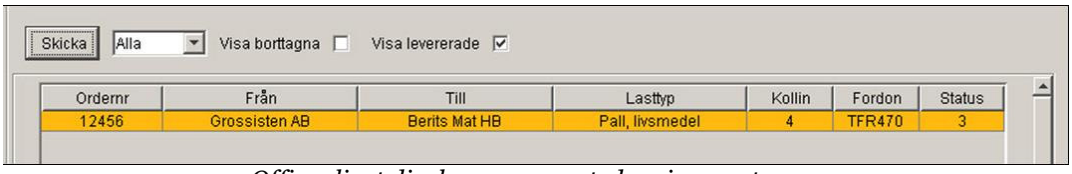
Office assignment overview

An order just received appears on the vehicle PDA. The yellow colour indicates that it has been sent successfully and that a driver response is expected. Clicking the blue text area brings detailed information on the assignment to view. After studying the detailed information view, the driver steps back to the assignments view to accept or decline the assignment. Clicking the coloured, in this case yellow, area brings forth the assignment status view. In the status view, the active assignment is shown together with the choices available to the driver. If the order is accepted, the status is changed accordingly. If the driver for some reason chooses not to accept the assignment, the assignment is deleted locally and reset on the office client. None of this will occur before the driver pushes the "verify & send" button.



Three vehicle displays; Assignment overview, assignment details and assignment status

As soon as the data holding the status change reaches the office client, the assignment changes colour. The dispatcher is thereby notified that this assignment is received and will be executed by the driver of the designated vehicle. When accomplishing subsequent tasks, such as loading and delivery, the driver performs further status changes, again changing the assignment colour notifying the dispatcher.



Office client displays an accepted assignment

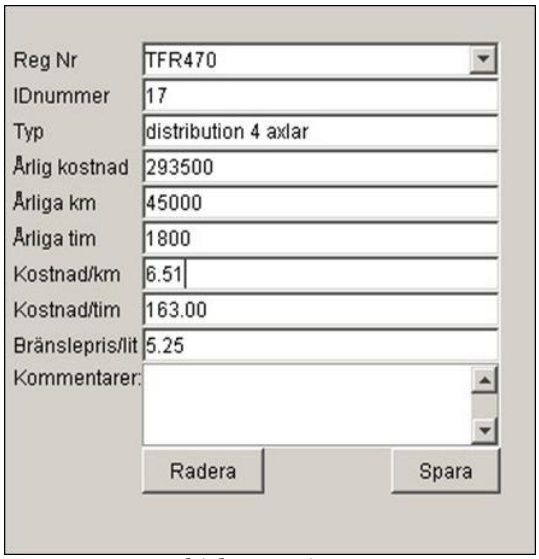
Should anything out of the ordinary happen, short messages can be added, using the notes view. These messages are coupled with the active assignment and contain a timestamp, thus serving as a future log.

Vehicle client notes view

Throughout the execution of assignments, CoDriver records vehicle performance data such as fuel consumption, mileage as well as time spent performing the various tasks described here. CoDrivers´ wireless communication ability ensures that this data is available at the office in seconds. This part of the prototype mainly handles the automation requirement noted earlier. In the next section, this information is used to create reports on the performance of the fleet, thus addressing the performance assessment requirement.

6.4 Use Case Scenario – Performance Assessment

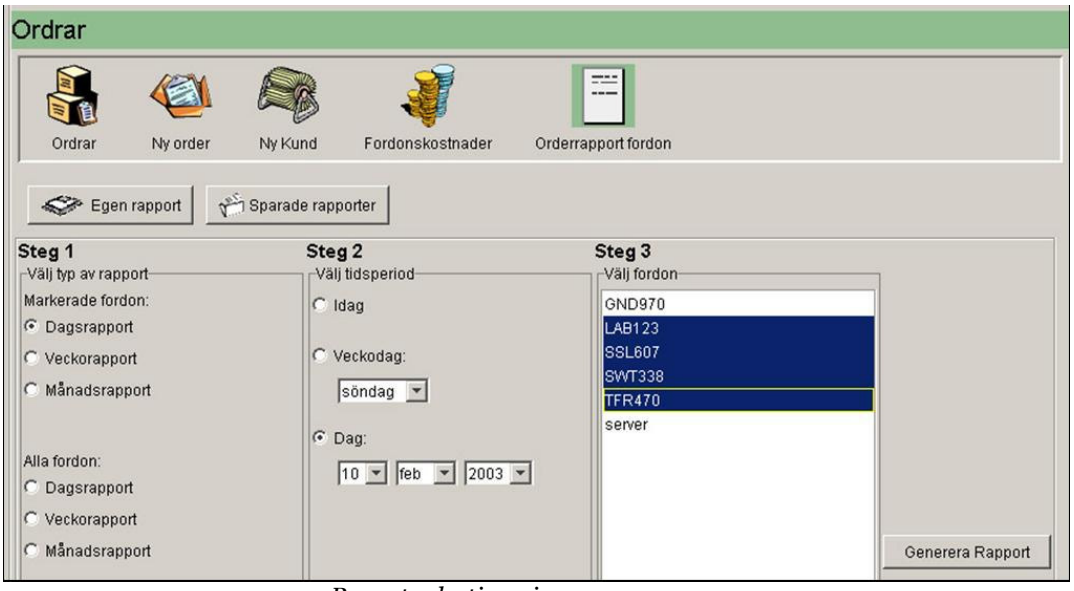
This section describes the production of reports building on the information on activities captured in the previous scenario. To create an activity report on a vehicle, it is essential that preparatory tasks have been executed. The cost calculation for the vehicles requires a number of important data. This is done in the vehicle cost view. The prototype currently contains no more than trivial support for calculating these numbers. It is assumed that detailed calculation is done elsewhere, possibly utilising other systems, and that the results from such endeavours are entered here. Naturally, this kind of support is of central importance in a fully-fledged TIS, but the limited resources available in this particular area would have made development impossible within the given temporal constraints. It should be noted that this is an area where road haulage firms utilise custom made or commercial off the shelf spread sheet applications. Therefore, this information is assumed to be available in one form or another to most road haulage firms.



Vehicle cost view

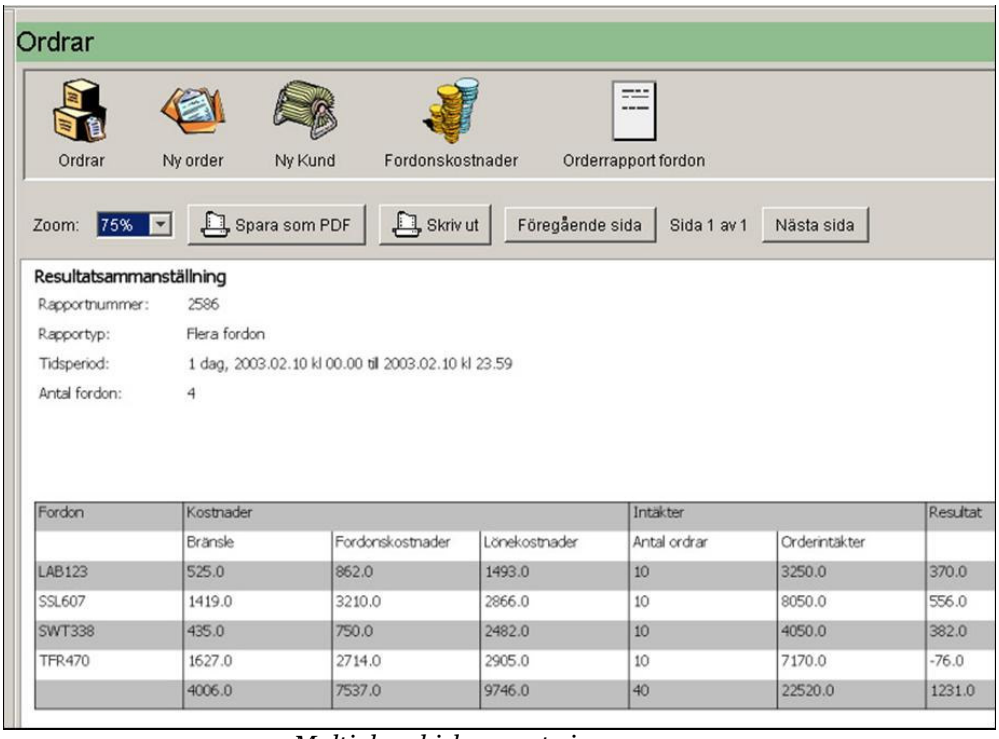
Having entered the prerequisite information, we proceed to the creation of a report. Presently, there are two variants of reports possible. A simple GUI requires the user to select a time period and whether all or just marked vehicles should be included. This choice will influence the design of the report

considerably, in that selecting a single vehicle will create a detailed report and several vehicles will create an overview of the vehicles selected.



Report selection view

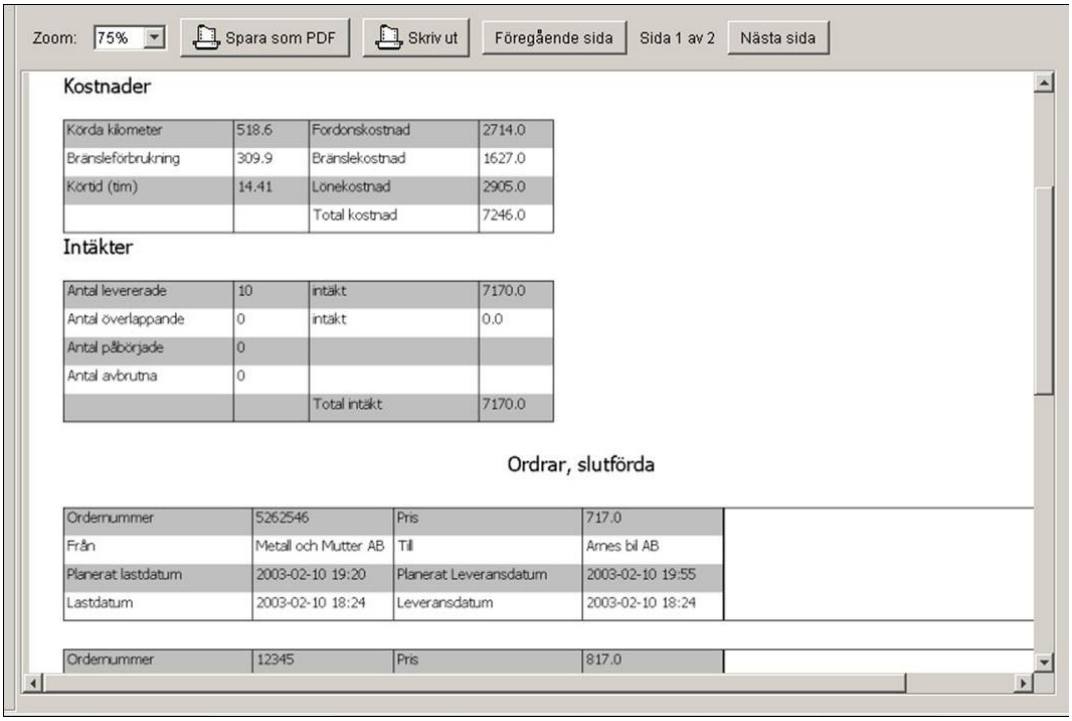
If, as depicted, several vehicles have been chosen, the report will contain brief information on the generated costs and profits for each vehicle throughout the selected period. The report can be saved in pdf-format or be printed right away.



Fordon	Kostnader			Intäkter		Resultat
	Bränsle	Fordonskostnader	Lönekostnader	Antal ordrar	Orderintäkter	
LAB123	525.0	862.0	1493.0	10	3250.0	370.0
SSL607	1419.0	3210.0	2866.0	10	8050.0	556.0
SWT338	435.0	750.0	2482.0	10	4050.0	382.0
TFR470	1627.0	2714.0	2905.0	10	7170.0	-76.0
	4006.0	7537.0	9746.0	40	22520.0	1231.0

Multiple vehicle report view

When only a single vehicle is chosen, a more detailed report is displayed. Costs are dealt with more meticulously. The individual assignments are also displayed. Information includes the aforementioned log of notes recorded throughout the assignment.



Single vehicle report view

Both reports are intended to grant the user with a swift overview and assist in finding the direction in which to focus his or her attention when searching for potential of improvement. Deviations are easily spotted and a more thorough analysis can commence. Eliminating a tedious time consuming search through multiple sources of documentation, stifling the initial effort of trouble shooting, the user will hopefully be encouraged to delve deeper and use other sources of information to pinpoint the exact nature of the problem.

7. Evaluation and Discussion

This prototype has been exhibited in a number of settings. It has been demonstrated at the SITI annual conference in Stockholm in February 2003 where it received positive comments from attendants. It has also been subject to discussion both in the software company developing the CoDriver platform and a large road haulage firm. As previously mentioned an application of this kind needs a substantial infrastructure. Information from several parts of a road haulage firm is needed to realise the full potential of the prototype. This generally means integrating existing systems as well as the processes they encompass. As there was no opportunity to integrate CoDriver with a dispatch system, the prototype could not be tested in an every day work practice. Instead, the prototype was shown to a number of key representatives from a large road haulage firm, who discussed the functionality and its wider implications. Notes were taken throughout this discussion, forming the basis of this discussion. Several interesting topics surfaced. What follows is an attempt at extracting the main points. As the prototype is dependant on various monitoring mechanisms, some concern was raised about acceptance from different user groups. There are also external issues that greatly affect the prototype.

First, it is important to consider drivers' reaction towards a scenario where their actions are monitored by dispatchers at all times. While this is a general concern for the much of the IS-support used by road haulage firms today, this prototype is no exception. This study indicates a concern among road haulage firms regarding the potential effect on drivers' attitude towards system support. The contradiction between how technology on the one hand can facilitate work processes, increasing the leverage of line management and on the other hand facilitate surveillance of employees is a topic previously addressed by for example Orlikowski (1991). Secondly, for the prototype to work, cooperation from both dispatchers and drivers is critical. Erratic use by drivers will result in poor quality data, thus diminishing the reliability of the final reports. According to Grudin (1994), motivation for system use demanding additional work is low if there are no direct benefits for the individual performing the work. A potential example of this phenomenon is that although awareness of assignment status is important for efficiency of traffic planners' work it does not necessarily entail

any direct benefits for the drivers. Instead, it might be perceived as just another additional task to perform. Such concerns can negatively influence use incentive among drivers, especially in combination with the previously mentioned issues regarding surveillance and reduced social interaction. Thirdly, in some cases there are constraints of business related nature. One aspect that surfaced in the dialogue with the road haulage firm was the structurally inherent difficulty of acquiring accurate price information on assignments carried out for a forwarding agent. In such cases, information on the revenue on assignments as well as payment is generally sent monthly from the forwarding agent. This greatly affects the possibility to accurately monitor the activities in the road haulage firm as analysis can only be performed at a monthly interval. This problem is of a structural nature and cannot be directly addressed by the prototype, although it might serve as an indication of the information needs of the road haulage firm vis-à-vis the forwarding agent. Overall, the idea received a positive feedback and the next step is to incorporate the functionality in a work setting, thereby testing its viability *in situ*. As part of the larger project, in which this study and prototype is an ingredient, further investigations will take place with the final goal of realising an introduction of the main features of the prototype to an active work setting.

8. Conclusion

Recent advances in telecommunications and mobile technology present road haulage firms with new challenges as well as possibilities for improvement. This thesis presents a first attempt to investigate perceived needs of TIS in the context of Swedish road haulage firms. Elaborating on the respondents' expectations, knowledge and assumptions of technology, a set of challenges likely to emerge around the implementation of TIS are outlined. However, further research is imperative in order to comprehend the challenges involved in designing and implementing TIS. As noted by Orlikowski and Iacono (2001), there is a need to concretise the technological artefact in order to theorise about its relation to the social context in which it resides. Investigations involving specific systems and a host of users of those systems will illuminate the challenges presented here, adding precision to the experiences pertaining to everyday use of TIS. In this thesis, TIS is used as a comprehensive concept

incorporating the enterprise wide needs of information technology expressed by road haulage firms. The prototype developed explores the future potential of an integrated systems environment by highlighting the use of automated vehicle performance data retrieval coupled with assignment information. However, in order to gain full advantage of such features when performing follow up on assignments, there are issues that need to be resolved. First, experiences indicate that integration is probably the way forward, as opposed to a monolithic architecture where all functionality resides in a single system. Such a path was not available when developing this prototype and the potential benefits of such a solution would therefore need further research. Secondly, the attitudes of various user groups can greatly affect the usefulness of the assessment capabilities suggested by the prototype. Thirdly, there exist inherent difficulties in acquiring the information necessary to perform timely analysis. Road haulage firms that have no direct access to the actual revenues of their assignments will have less opportunity to proactively separate the cash cows from the less profitable assignments.

Appendix; Questionnaire

These are the areas of inquiry used throughout the interviews. The questions were designed to produce discussions rather than closed answers. This open structure allowed respondents to reflect on questions about technology use, nature or strategy, and about organisational structure and tasks in relation to technology, without prior understanding of the specifics of individual organisations. At the same time, the structuring served as a means to focus on the same general set of issues in all interviews, thus enabling later analysis.

- Name and job description
- Describe the structure of the organisation

  (Customers, fleet size, personnel, ownership)
- Describe main/core activities

- What IT-support is used presently?

  (Office systems, vehicle systems)

  For each mentioned above:
- Why was this (system) purchased/developed?
- What effects has it had?

  (Room for discussions on the merits of the system in question and potential improvement suggestions)

- Are there any other areas in which you see a need for IT-support?

  (Include motivation)

  For each mentioned above:
- What would that IT-support preferably look like?

  (Descriptions of features and/or experiences/knowledge/assumptions of commercially available systems)

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